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ABSTRACT

This document presents the Alabama State Department of Education guidelines for science laboratory safety, equipment, storage, chemical safety, rocket safety, electrical safety, safety with radioisotopes, and safety with biologicals. Also included is a brief bibliography, a teacher's checklist, a listing of laser facts and regulations, and a listing of Alabama laws relative to safety goggles. (SL)

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LABORATORY SAFETY MANUAL

FOR

ALABAMA SCHOOLS

State of Alabama
Department of Education
Montgomery, Alabama

Bulletin 1975, No. 20

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LeRoy Brown
State Superintendent of Education

J. C. Blair, Director
Division of Instruction

State of Alabama
Department of Education
Montgomery, Alabama

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PREFACE

Modern science instruction requires active participation by the student. This expanded contact with scientific equipment increases the possibility of accidents. Many students will not be familiar with laboratory procedures and may not possess the necessary skills to safely experiment.

A good safety program has several components.

1. Safety instruction
2. Adequate quantities of operable safety equipment
3. Physical arrangement of furniture and facilities conducive to safety
4. Established procedures and rules posted and frequently evaluated

Instruction in safety procedures should be an integral part of each laboratory exercise. An attitude of alertness to dangers coupled with good common-sense practices should permeate the science laboratory and classroom.

Safety is a way of life. Principles learned and used in the laboratory will carry over to the home and other life situations.

LeRoy Brown
State Superintendent of Education

SAFETY GUIDELINES, EQUIPMENT AND STORAGE

A. Suggested laboratory safety guidelines[8]

All laboratory experimentation should be governed by sound, well-established rules and procedures. The following rules are suggested. Teachers are encouraged to add to or delete from this list. It is strongly recommended that each teacher establish, post, and frequently review rules and procedures.

1. All experiments performed will follow safe, acceptable procedures, as outlined in a laboratory manual.

2. Students should be supervised by a teacher or a reliable assistant during laboratory experimentation.

3. Experimenters should point their test tubes away from themselves and others when heating substances.

4. When diluting concentrated acid, one should always add the acid to the water, pouring the acid slowly and carefully into the water. Stir gradually to spread heat.

5. Acids spilled on clothing or laboratory areas should be neutralized with limewater, diluted ammonium hydroxide, or sodium bicarbonate.

6. Bases spilled on clothing or laboratory areas should be neutralized with diluted acetic acid.

7. Highly corrosive chemicals should be handled with care. If they come in contact with the skin, flush immediately with tap water. Labels on these containers should be protected by wax or some other means.

8. Students should never taste chemicals unless they are directed to do so by the instructor.

9. When objectionable or poisonous gases are to be produced, perform the operation under a Fume Hood.

10. Aprons should be worn during experimentation. Dangerous chemicals should not contact the skin.

11. Students should read the label on a chemical bottle at least twice before removing a sample. This is a standard procedure in industry and pharmacies.

12. Laboratory apparatus should not be carried through hallways while students are in transit.

13. When using volatile, flammable liquids such as ether, care must be taken to avoid flames.

14. Dangerous combustible materials of all types are to be kept in a metal cabinet equipped with a workable locking mechanism.

15. Chemical containers should have their caps or stoppers tightened at all times.

16. In performing experiments where there is a possibility of spattering, or a slight chance of a serious flash or explosion, the following precautions should be observed:

    a. Keep students a safe distance from the demonstration (8 ft. suggested).

    b. Develop a shield of strong, fine wire mesh, wire glass, or ordinary glass to protect students as well as the teacher. Commercially prepared shields are available from chemical supply houses.

17. When inserting glass tubing or rods into rubber stoppers, observe the following precautions:

    a. Tubing having a jagged end should be fire-polished or beveled with a file.

    b. Use water-soap solution or glycerin as a lubricant and force the tube by using a twisting motion.

    c. Always hold the tubing as close to the stopper as possible.

    d. Wrap a cloth around the hand or over the end of the tubing.

18. Ensure that all storage bottles are appropriately labeled.

19. Chemicals found in unlabeled bottles should be discarded as described in other sections of this manual. Unused chemical should not be returned to its container unless the teacher directs that this be done.

20. Bottles containing organic volatile liquids or concentrated acids should never be placed near heated pipes, in direct sunlight, or above the bottom shelf in the storage room.

21. A container of dry ice should not be sealed.

22. Rags containing highly flammable organic solvents and any explosive waste chemicals should be carefully disposed of in a fireproof receptacle.

23. Glass and steel wool should be handled carefully to avoid splinters.

24. Teachers should report all accidents to the principal and refer the more serious ones to a physician.

25. Students should be specifically instructed at the beginning of each laboratory period regarding any new procedures and the precautions required.

B. Safety equipment

It is imperative that an adequate supply of safety equipment be on hand at all times. It should be located in places that are readily accessible in case of

emergencies. The safety equipment should be checked periodically for operability, and students should be taught how to properly use each type.

1. Fires and fire extinguishers

   a. Fires are classified as to the type of combustible material.

      Class A: Ordinary materials such as wood, paper, etc.

      Class B: Flammable liquids such as greases, oils, paints, etc.

      Class C: Electrical equipment such as motors, switches, etc.

   b. Fire extinguishers are specifically designed for certain type fires.

      (1) For B and C type fires use carbon dioxide extinguishers.

      (2) For A, B, and C type fires use the multipurpose dry chemical extinguisher. This type extinguisher is more versatile than the CO_2 type.

After using a fire extinguisher, check it for operability and have it recharged if the gauge indicates the need.

2. Fire blanket

   A fire blanket should be placed in a convenient location and students shown how to best utilize it.

3. Safety shower

   A safety shower should be placed in any laboratory where caustic or harmful chemicals are used. A simple form of shower can be made by putting in a T pipe on the instructor's desk and connecting a valve and a rubber hose to the T.

4. Safety goggles (Refer to Appendix B)

   Alabama law requires every student or teacher to wear industrial quality eye protective devices while participating in chemical or combined chemical-physical laboratories involving caustic and explosive chemicals or hot liquids or solids.

   Industrial quality eye protective devices means devices providing side protection and meeting the standards of the American Standards Association Safety code for Head, Eye, and Respiratory Protection (1965, 1st Executive Session, P. 219, Approved April 5, 1965).

5. Aprons, gloves, forceps and tongs

   Students should be encouraged to wear aprons to protect clothing in all laboratories and required to wear aprons in laboratories where caustic

or dangerous chemicals are used. Gloves are necessary in cleanup of spills and destruction of unwanted chemicals. Forceps and tongs of the proper kind are necessary in handling hot equipment. Hazardous chemicals should not contact the skin.

6. Fume hood

A fume hood is recommended for working with many chemicals, and it is essential for all obnoxious and poisonous gases. Permanent fume hoods are preferred but portable type hoods can be used successfully if proper installation provisions are made.

7. Emergency first aid procedures[11, 12]

Science teachers should become knowledgeable in well-established, up-to-date first aid procedures. The following procedures are approved but they are not intended as a medical guide.

Cuts

When the cut is minor, wash and remove any chemicals with soap and water, then get medical attention. If the blood is spurting, place a sterile gauze pad directly on the cut, apply firm direct pressure, wrap the injured to avoid shock, and get immediate medical attention. NEVER USE A TOURNIQUET. In case of a less severe cut, wash, remove any pieces of debris, wrap the injured to avoid shock, except in case of a trivial cut, and get medical attention.

Thermal burns

Immediately submerge the burned area in cold water. Repeat if pain returns. For the more serious burns do not break blisters or remove tissue. Do not use antiseptic preparations, ointment, spray, or home remedies. All serious burns are to be referred to a physician. Watch for signs of shock and give immediate first aid as mentioned elsewhere in this manual.

Chemical burns

Immediately flush the affected area with large amounts of cold water, using a shower or hose, if available, and continue for at least 5 minutes. Remove the victim's clothing from affected areas. If the burn is not visible, scrub the area with warm water and soap. If any present or future damage is suspected, secure medical attention. Acid burns may then be soothed with a dressing soaked in a solution of bicarbonate of soda (1 teaspoonful to a glass of water). Alkali burns may be rinsed with a mild solution of vinegar water after the initial washing.

Chemicals in the eye

Immediately flush the eye with copious amounts of water under gentle pressure. The injured's head should be held to one side and the eye kept open to allow water to flush the chemical out of the affected eye. An eye-wash fountain should be used, when available, and the eye must be kept open to wash behind the eyelid. Prompt medical attention must be secured. "The use of contact lenses should not be permitted in a chemical laboratory."[12]

Electric shock

Remove the plug or turn the switch off on the device affecting the victim. Do not touch the person while he is in contact with a live circuit. Secure a dry board, stick, or some type nonconductor and lift the wire to remove the victim. If his breathing has stopped, start artificial respiration at once. If a resuscitation unit is not available, use mouth-to-mouth resuscitation as recommended by the American Red Cross. After breathing resumes, keep the patient comfortably warm in a semi-reclining position.

Shock treatment

There are several forms of shock and the word has many meanings. Shock can be caused by the passage of an electric current through the body. It can be caused by a violent reaction to an allergen, such as the poison from a bee sting or some serum to which the individual has become sensitized. Additionally, shock may be caused by fall in blood pressure accompanying poisoning or following a severe injury.

When the patient shows sign of shock have him lie down on a blanket and raise his feet above the height of his head. If there is a head or chest injury, raise the patient's head above his feet. Keep him comfortably warm. Fluids may be given if medical help is not available in an hour. Offer the patient tea with sugar, carbonated drinks, or orange juice. When available, shock solution should be given at the rate of four ounces every fifteen minutes for adults and two ounces every fifteen minutes for children ages 1 to 12. Shock solution is made by mixing one teaspoonful of table salt and 1/2 teaspoonful of baking soda to each quart of water. Fluids should not be given if there appears to be abdominal or brain injuries. If the patient vomits, discontinue fluids.

Poisoning by venomous snakes and spiders

Teachers should know how to identify poisonous snakes and spiders that are prevalent in the local school area. All precautions are to be taken to avoid contact with venomous snakes and poisonous spiders. If a student is bitten by a venomous snake or spider he should immediately be given medical aid by a physician. In cases where there might be a time delay, it is advisable to carry a snakebite kit on field trips and the instructor should be familiar with first aid procedures as outlined in the First Aid Manual published by the American National Red Cross.

Miscellaneous

In addition to first aid problems presented there are other plants, animals, and chemicals that are potentially dangerous--jellyfish, Portuguese man-of-war, corals, insect bites, ticks, scorpions, several species of fish--and the first aid measures should be known by the instructor.

8. The first aid kit should be available in the laboratory with access to the student as well as the teacher. A commercially prepared kit is preferred. The kit should be examined for content and should contain, in satisfactory quantity: gauze bandage (2 in. x 126 in.), gauze bandage (3 in. x 126 in.), gauze bandage (1 in. x 126 in.), gauze (8 ply, 4-1/2 in. x 36 in.),

cotton (1 oz.), gauze pads (2 in. x 2 in.), gauze pads (3 in. x 3 in.), gauze pads (4 in. x 4 in.), adhesive bandage (1 in.), amoply ammonia inhalants (4 cc), tongue depressors, eye pads, swabs, scissors, burn ointment (Foille or a substitute), tweezers, adhesive tape, triangular bandage, first aid cream, and petroleum jelly.

9. Eye wash station

If emergency eye-wash fountains are used, they should deliver a gentle flow of clean, aerated water. A hand-held eye-wash spray with a 5-foot hose is more adaptable to unusual situations, including head and body splashes. Eye-wash devices or hoses should be flushed at least weekly. For chemical splashes, very complete irrigation is necessary (for eyes, a 15-minute flush is recommended).

C. Safety in storage

All storage areas should be kept clean, orderly, well-lighted, and should be provided with doors that can be securely locked. Cleanliness and orderliness are very important factors in the safe operation of laboratories. All unnecessary empty containers, broken or unserviceable equipment, and "junk" should be promptly discarded.

All laboratory equipment of a metallic nature, subject to damage by chemicals, should be stored separately from chemicals.

The chemical storage area should be equipped with a mechanical or electrical ventilating system and rimguard shelves. Large containers of acids and concentrated caustic solutions should be stored on shelves nearest the floor.

When the temperature is below freezing and schools are to be closed, science personnel should be alerted to the possibility of freeze damage to such items as fire extinguishers, plants and animals, aquariums, acids, ammonia, biology specimens, chemicals in solutions, distilled water, and water covering yellow or white phosphorus.

CHEMICAL SAFETY

The chemical storage section of the laboratory is potentially the most dangerous. It is essential that teachers frequently inspect the area and correct all problems.

A. Incompatible chemicals

Incompatible chemicals are chemicals which may react together and create an explosive or hazardous condition. These chemicals should not be combined in experiments, and they should be stored in such a manner as to avoid accidental contact. The following list is not complete. For information concerning a particular chemical, contact the State Department of Education science specialists or refer to the Laboratory Waste Manual (September 1973) published by Manufacturing Chemists Association. (Refer to Bibliography for address.)

Examples of Incompatible Chemicals:[7]

Chemical	Avoid Contact With
Acetic Acid	Chromic acid, nitric acid, peroxides, permanganates, ethylene glycol, perchloric acid.
Acetylene	Chlorine, bromine, fluorine, copper, silver, mercury.
Alkaline Metals (Sodium, Potassium and Powdered Aluminum, Magnesium, etc.)	Water, carbon tetrachloride, carbon dioxide, halogens, chlorinated hydrocarbons.
Ammonium Nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulphur, any finely divided organic or combustible substance.
Chlorine and Bromine	Ammonia, petroleum gases, hydrogen, sodium, benzene, finely divided metal.
Fluorine	ISOLATE FROM EVERYTHING.
Aniline	Nitric acid, hydrogen peroxide.
Chlorates	Ammonium salts, acids, metal powders, sulphur, any finely divided organic or combustible substance.
Chromic Acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids in general.
Copper	Acetylene, hydrogen peroxide.
Flammable Liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, the halogens.
Hydrocarbons (butane, benzene, gasoline, etc.)	Halogen gases, chromic acid, sodium peroxide.
Hydrocyanic Acid	Nitric acid, alkali.
Hydrofluoric Acid	Ammonia, aqueous or anhydrous.
Hydrogen Peroxide	Most metals and their salts, alcohols, organic substances, combustible materials.
Hydrogen Sulfide	Oxidizing gases, fuming nitric acid.
Iodine	Acetylene, ammonia, hydrogen.
Mercury	Acetylene, fulminic acid, ammonia.

Chemical	Avoid Contact With
Nitric Acid, concentrated	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids and gases.
Oxalic Acid	Silver, mercury.
Perchloric Acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood.
Potassium Chlorate	Sulfuric and other acids, any organic substances.
Potassium Permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid.
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds.
Sodium Peroxide	Ethyl and methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethlene glycol, ethyl acetate, methyl acetate, furfural.
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with Light metal, such as sodium and lithium).

B. Safety with heavy metals, alkali metals, mercury, and phosphorus.[2]

The term "heavy metal" is nonspecific and seldom defined. In a general sense, a heavy metal is any element with metallic properties and a specific gravity greater than five.

Except for unusually hazardous compounds, the laboratory use of heavy metal compounds will not require any precautions other than those used with most chemicals. Material spilled on the skin should be washed off immediately; splashes in the eyes require immediate and thorough flushing with water plus follow-up medical attention. Spills of gram quantities can be washed down a sink drain or added to other laboratory waste for later disposal. Large quantities require special handling.

1. Heavy metal

   a. Examples: arsenic, antimony, bismuth, lead, and cadmium.

   b. Wear: rubber gloves, safety glasses, respirator, laboratory coat, and work with a fume hood.

   c. Spills and package lots: If a small quantity is involved treat as <u>inorganic salts</u>, as outlined on page 10 in this manual.

2. Mercury

a. Examples: mercuric nitrate, chloride and thiocyanate; mercurous nitrate and chloride; mercury; organic mercury compounds.

Caution: Mercury and its compounds are highly toxic and should not be allowed to contaminate air or water.

b. Spills and package lots:

Metal: Collect all droplets and pools of liquid mercury at once, using a water suction pump and an aspirator with a long capillary tube or use a commercially prepared mercury brush. Cover the fine droplets in inaccessible spots with sodium polysulfide solution or powdered sulfur. Keep all contaminated mercury in a tightly stoppered bottle.

Mercury compounds: Dissolve all water-soluble contaminated compounds. Convert other contaminated compounds to the soluble nitrates. Adjust the acidity and precipitate as mercuric sulfide. Wash and dry the precipitate. Ship to the supplier.

3. Yellow phosphorus

Spills: Cover with wet sand. Spray sand to keep wet. Scoop into a pail of water. After standing overnight, re-cover and repackage. If the quantity is very small, cover with water and remove to an open area. Pour onto the ground. Water will evaporate and phosphorus will ignite spontaneously.

4. Red phosphorus

a. Spills: Sweep up and burn on an iron pan in the hood.

b. Defective package: Repackage and return to the shelf or supply house.

First aid for phosphorus burns: White phosphorus burns on contact with the skin. Immediate and prolonged flushing with water is essential. Red phosphorus is an eye irritant. Flushing with water is essential and prompt medical attention is necessary for all phosphorous burns.

Phosphorus storage: White phosphorus must be stored under water with a p^H below 9. Reaction with alkalies may form a toxic gas phosphine PH_3. Red phosphorus is less dangerous than white or yellow but can be converted to the gas phosphine with prolonged exposure to the air. White phosphorus causes bone damage and is dangerous.

5. Alkali metals

The most hazardous properties of the alkali metals are their flammability and violent reactions with water.

a. Examples: sodium, lithium, potassium

b. Storage: These metals are to be stored under a layer of kerosene or similar hydrocarbon. The covering liquid must be free of moisture and halogenated hydrocarbons. Toluene is a better liquid for covering sodium.

c. Spills: Cover the area with dry soda ash (Na_2CO_3). Mix the soda ash and alkali metal together and add slowly to butyl alcohol. After 24 hours dilute and add to the drain with a large excess of water. The use of ethyl or methyl alcohol may cause the solution to become ignited.

d. Fires: Dry soda ash (Na_2CO_3) is the recommended extinguishing agent for sodium and potassium. Powdered lithium chloride and sodium chloride are recommended for lithium fires. Powdered graphite is effective on all alkali metals.

C. Chemical disposal procedures.[1]

Do not dilute undesirable chemicals with water and dump down the drain. Neither is it advisable to indiscriminately bury or incinerate chemicals.

It is imperative that the following procedures be followed, as they are based on the conversion of wastes to less toxic or harmless forms or neutralization, so that septic tanks or sewage systems will not be harmed.

Safety precautions. In removing chemical spills or destroying undesirable chemicals, the teacher should wear safety goggles, gloves, and a laboratory apron. For more active agents, a face or body shield and a self-contained breathing apparatus should be used.

1. Organic acid halides

   a. Examples: acetyl chloride, oxalyl chloride, etc.

   b. Spills: Cover with sodium bicarbonate. If a small quantity is involved, scoop the mixture into a large beaker of water and let stand for a few minutes. Slowly pour into the drain with copious amounts of water. If a large quantity is involved, scoop the resulting bicarbonate mixture into a plastic bag, cardboard box, or small fiber drum. This material can then be burned in an incinerator or spread on the ground and flooded with water. The site of the spill should be washed with soapy water.

2. Inorganic halides

   a. Examples: aluminum bromide, anhydrous stannic chloride.

   b. Spills: Follow procedure 1.b above.

3. Aldehydes

   a. Examples: benzaldehyde, formaldehyde, etc.

   b. Spills: Eliminate all sources of ignition and flammables.

      Small amounts - Absorb on paper towel. Evaporate in the fume hood and burn the paper.

      Large amounts - Cover with sodium bisulfite ($NaHSO_3$). Add small amount of water and mix. Scoop into large beaker. After one hour wash down the drain with a large excess of water. Wash site with soapy solution.

4. Aliphatic amines

   a. Examples: amyl amine, butyl amine, etc.

   b. Wear: Butyl rubber gloves, face shield or all-purpose canister respirator, and laboratory coat.

   c. Spills: Liquid or solid - Cover with sodium bisulfate. Spray with water and wash into drain with large excess of water.

5. Organic phosphates and related compounds

   a. Examples: malathion, parathion, systox.

   b. Wear: rubber gloves, self-contained breathing apparatus, and laboratory coat.

   c. Spills: Absorb with vermiculite or paper towels. Scoop the mixture into a plastic bag. Take bag outside to incinerator or pad and burn. If an incinerator is not available, set the bag in a pan of waste flammable solvent and burn.

6. Carbon disulfide

   Spills: Eliminate flammables and all sources of ignition. Allow to evaporate or absorb with paper towels and evaporate in hood on an iron pan or glass dish. Burn the paper.

7. Caustic hydroxides and ammonia

   Spills:

   Solid - Sweep up, dilute and neutralize with 6M-HCl in a large bucket. Wash down the drain with a large excess of water.

   Solution - Neutralize and mop up - or use water-vac. Discharge to sewer with a large excess of water.

8. Inorganic salts

   a. Examples: alums, sodium iodide, zinc acetate.

   b. Spills:

      (1) Solution - Cover with soda ash, mix and scoop into a beaker of water. Neutralize with 6M-HCl and wash down drain with excess water.

      (2) Solid - Collect in a beaker. Dissolve in a large amount of water, add soda ash, mix and treat as above.

      If spill contains a fluoride, add slaked lime in addition to the above treatment.

9. Oxidizing agents

Examples: potassium and sodium perchlorates, chlorates, chlorites, dichromates, hypochlorites, permanganates, persulfates, perchloric acid, chloric acid, etc.

If the oxidizer is a liquid or a solid, cover with a reducer (hypo, a bisulfite or strong reducing agents). Mix well and spray with water. A sulfite or a ferrous salt will require addition of some 3M-H_2 SO_4 to promote rapid reduction. Scoop slurry into a container of water and neutralize with soda ash. Wash down the drain with excess water. Wash site thoroughly with a soap solution containing some reducer.

10. Reducing substances

Examples: chromous salts, sodium bisulfite, sodium sulfite, sodium thiosulfate, stannous chloride, and sulfur dioxide.

Solid: Cover spill with soda ash or sodium bicarbonate. Mix and spray with water. If effervescent, wait until reaction is complete. Scoop into a large beaker and cautiously add equal volume of calcium hypochlorite (reaction may be vigorous). Add more water, stir, and allow to stand for one hour. Dilute and neutralize the oxidized solution and transfer to the drain with excess of water.

11. Cyanides and nitriles

a. Wear: long rubber gloves, self-contained breathing apparatus, laboratory apron or coat. Evacuate the room and isolate the areas during decontamination.

b. Spills: Eliminate all sources of ignition and flammables.

(1) General treatment:

(a) Absorb liquid with vermiculite or on paper towel (sweep solid onto paper). Place on an iron or glass dish in a hood. Evaporate and burn paper.

(b) On skin - Wash away immediately with much soap and water.

(2) Cyanides:

(a) Scoop into a larger beaker and make alkaline with sodium hydroxide solution. Add to the slurry an excess of ferrous sulfate solution. After one hour, flush down the drain with excess water.

or

(b) Add excess sulfur to the alkaline slurry of the cyanide. Heat to convert to thiocyanate. Flush down the drain with excess water.

(3) Nitriles:

Add excess of sodium hydroxide and calcium hypochlorite solution to

produce a cyanate. Scoop slurry into a large beaker. After one hour flush down the drain with excess water. Wash site with soap solution containing some hypochlorite.

12. Ethers

Spills: Eliminate all sources of ignition and flammables. Absorb on paper towel. Evaporate from an iron pan in a hood. Allow time for vapors to completely escape the hood vents, then burn the paper.

If large spill, absorb on much more paper or vermiculite and allow complete evaporation from all surfaces. Use same precaution before burning paper.

PEROXIDE FORMATION. (See MCA Data Sheet SD-29 ethyl ether.)
Ether of long standing in contact with air and exposed to light may contain peroxides especially if stored in clear glass. Explosions have occurred when caps or stoppers were turned. (See MCA Accident Case History No. 603.) MCA address is listed as #1 in this Bibliography.

13. Hydrocarbons, alcohols, ketones, and esters

Spills: Eliminate all sources of ignition and flammables

a. A liquid - Absorb on paper. Evaporate on an iron pan in a hood. Burn the paper.

b. A solid - Sweep onto paper and place on an iron pan in the hood. Burn the paper and compound.

14. Inorganic Peroxides

a. Examples: Hydrogen peroxide (3% to 90%), sodium and potassium peroxide.

b. Spills: Cover with at least double volume of sand-soda ash mixture (90%-10%). Mix thoroughly and break up any lumps of peroxide. With a plastic scoop add slowly to a large beaker of sodium sulfite solution (3 to 4 liters) with stirring. Neutralize with diluted sulfuric acid. When settled, decant the sulfate solution into drain with excess water. The sand can be sent to the landfill.

Hydrogen Peroxide (spill or package lots): Dilute and wash down drain with excess of water.

15. Organic Acids (Limited to C, H, & O Composition)

Spills: Eliminate all sources of ignition. Cover contaminated surfaces with soda ash or sodium bicarbonate. Mix and add water if necessary. Scoop up slurry and wash neutral waste down drain with excess water. Wash site with soda ash solution.

16. Inorganic acids

Spills: Cover the contaminated surface with sodium bicarbonate or a soda ash-slaked lime mixture (50-50). Mix and add water if necessary to form a slurry. Scoop up slurry and wash down the drain with excess water. Wash site with soda ash solution.

17. Carbides

Spills: Cover with dry vermiculite, scoop into a dry bucket or plastic bag, and transfer to a safe open area. Dispose of the material cautiously by adding it slowly to a large volume of water. Burn the hydrocarbon gas using a pilot burner. Allow to stand for 24 hours and run to sewer with excess water.

ROCKET SAFETY

The construction of amateur rockets and the synthesis of fuels are unsafe and therefore discouraged. It is recommended that the study of rockets and other projectiles activated by pyrotechnic devices and other chemical reactions be accomplished by wide reading and discussion of theory, principles, and structural design.

Commercially available devices, such as rockets powered by compressed cold gases, cold liquids, or small prepackaged motors, may be used in controlled and supervised experiments.

The supervising teacher must ensure that safe conditions exist during these experiments. Such conditions include the following:

1. An area designated for rocket experimentation must be used, and all personnel not connected with the experiment must be barred from that area during experimentation.

2. The area must be large enough to permit safe recovery of the expended rockets under all conditions (winds, projection, etc.).

3. The participants must be protected during lift-off by a sturdy, explosive-resistant shield, such as a wall, sandbags, or a bunker. Lift-off must be accomplished by remote control.

4. The participants must be adequately protected from the device during free fall.

ELECTRICAL SAFETY

A. Electrical Safety

1. Most electrical devices are hot after use, and serious burns may result. Cautious handling of such devices is recommended.

2. Dry cells and storage batteries should not be short-circuited as this will discharge the cell and will heat the wire, thereby creating a possible hazard.

3. The secondary portion of induction coils pose a possible danger.

4. The male plug on an extension cord should be grasped and pulled from the outlet rather than grasping the cord.

5. Extension cords should be regularly inspected for defects and promptly repaired.

6. Caution should be taken when using a storage battery, due to the acid it contains and the high amperage.

7. Equipment containing capacitors (TV sets, oscilloscopes) should be shielded to avoid fatal shock.

8. One hand should be used when working with a "live" portion of a circuit.

9. Blown fuses should be replaced with fuses of the same amperage.

B. Radiation from electronic devices

The use of X-ray and other such radiation equipment should be made only by experienced personnel. Electron emission equipment should not be used on students for any purpose.

All devices which use electron beams (cathode ray tube, television picture tube) must be shielded when in use to prevent human exposure to radiation.

C. Using lasers and masers (Refer to Appendix A)

Laser and maser devices utilize the natural oscillation of stems for amplifying or generating electromagnetic waves. Experimenters with these devices should comply with a directive issued January 5, 1973, by the Alabama Department of Public Health.

D. Using microwave devices

Microwave exposure can cause skin burns and may affect the eyes and other organs. The degree of physical harm that may be produced depends on both the intensity of the radiation and the duration of exposure, and may depend on the frequency as well.

The only way to determine if a given device is emitting harmful microwave radiation is to have it tested by a special device. Contact the State Radiological Health Officer.

SAFETY WITH RADIOISOTOPES[7]

Teachers must give attention to regulations of the Atomic Energy Commission relating to the possession and use of radioactive materials and by-products. Personnel who work with radioactive chemicals should be knowledgeable in techniques to be employed while experimenting with these materials. The Atomic Energy Commission will give assistance to local schools. The following precautions should be followed in handling radioisotopes:

A. All open radioactive liquids should be handled over a tray lined with absorbent paper or with newsprint.

B. Rubber gloves should be worn for preparative work, but are rarely used when counting samples in order to prevent contamination of counting equipment. They should be monitored by another person for contamination while they are still on the hands.

C. Spills should be wiped immediately with absorbent paper (wear rubber gloves) and the paper placed in a special container for radioactive waste disposal.

[7]Special permission granted by Current Science/Science and Math Weekly, published by Xerox Education Publications.

D. Samples are prepared for counting by adding the reaction system to a small shallow cup called a planchet. Dry the cup or planchet and spray it with a transparent plastic lacquer like Krylon. Keep spray off an alpha emitter.

E. Keep all acids away from ^{131}I and ^{14}C solutions or use under hood in proper working order. Use this method when a radioactive gaseous product is expected.

F. Before leaving the laboratory after radioactive materials have been used, the working area, hands, and clothing should be monitored for contamination with a Geiger counter.

G. All glassware used in radiation experiments must be decontaminated before being used again. Scrub well and rinse with plenty of running water. Decontaminate glassware by soaking in chromic acid bath consisting of 100 g of potassium dichromate and 600 ml of water with 400 ml concentrated H_2SO_4. Discard if still contaminated. Monitor with Geiger counter for residual radioactivity which should be no higher than background count.

H. Disposal: All material which cannot be decontaminated should be put in a lined storage can marked for disposal of radioactive waste. The workbenches and floors can be cleaned by repeated scrubbing with a strong cleaner. One laboratory sink should be designed for the disposal of radioactive waste and rinsings and called "Hot Sink."

I. Storage: Radioactive materials should be kept separated in a small cabinet that can be safely locked. A small tin can or a plastic box can provide proper shielding for exempt quantities. A film badge or dosimeter does not have to be worn when working with license-exempt quantities.

SAFETY WITH BIOLOGICALS

A. Experiments with bacteria

When culturing micro-organisms such as bacteria, there is always the possibility of contaminating a desired form with pathogenic forms. For this reason the best sterile techniques should be followed in using cultures. The culturing of pathogenic organisms in elementary and secondary schools is discouraged. Such culturing requires strict supervision of a person thoroughly acquainted with the knowledge of aseptic techniques. Nonpathogenic bacteria are safe to handle if a few rules are followed, such as:

1. Eating should not be allowed in laboratories.

2. When inoculating bacteria, the wire loops must be heated in a flame <u>before</u> and <u>after</u> <u>use</u>.

3. Spilled culture should be disinfected with a 10% Lysol solution before removal with an absorbent material.

4. Slides that have been used in bacterial examination must be soaked overnight in a 10% Lysol solution.

5. Before discarding, cultures must be autoclaved or destroyed by heat in a pressure cooker.

6. At the end of the laboratory period, laboratory tables should be cleaned with a 1% Lysol solution and the hands washed thoroughly with soap and water.

B. Safe handling of poisonous plants and animals

The caging of live poisonous animals is discouraged. The neurotoxin of spiders and coral snakes is highly toxic and can be deadly. The hematoxin of pit viper snakes can be deadly.

Some students are extremely allergic to poison ivy, oak, and sumac. It is advisable to enclose these plants inside sealed plastic sheets if they are to be displayed in a room. With the thought of student allergy in mind, it is advisable for science teachers to know the students who are allergic to animal stings or bites, and those who have allergies to poisons, pollens, etc., before taking a field trip.

C. Blood typing

It is possible to transmit hepatitis from person to person by using unsafe techniques. In blood typing, a sterile lancet should be used each time and fingers cleaned with isopropyl alcohol before pricking.

D. Formalin and preservatives

Preservatives may cause eye and body irritation. Specimens should be washed in tap water before dissection. Some newer type preservatives have replaced formalin and seemingly are not as irritating. Washing specimens in tap water should remove the irritant.

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TEACHERS' SAFETY CHECKLIST

It is recommended that this checklist be used to assess the local school safety program.

A. Safety practices

____ 1. Are you aware of local or State regulations which relate to school safety?

____ 2. Is a science instructor present at all times when students are working in a classroom or laboratory?

____ 3. Are regular laboratory inspections made and the results recorded?

____ 4. Is the teacher thoroughly familiar with local fire regulations and school plans for fire drills?

____ 5. At the beginning of experiments, where there are special hazards, are students specifically instructed regarding the recognition of dangers and the precautions to be taken? (This includes study trips as well as laboratory experimentation.)

____ 6. Are all accidents or injuries--no matter how small--reported to the teacher immediately?

____ 7. Is equipment that has been heated allowed to cool before it is moved, and are hot objects always picked up with tongs or gloves?

____ 8. Is there adequate warning in all areas where poisons, high voltage, radioactive materials, or pathogenic organisms are used?

____ 9. Do you occasionally check gas burners for defective tubing and gas leaks?

____10. Are the students aware that it is unsafe to touch the face, mouth, eyes, and other parts of the body with the hands while working in a laboratory situation?

____11. Is eating forbidden in the laboratory?

____12. While using combustible materials, are all flames extinguished?

____13. Since mercury is a volatile and highly poisonous, dangerous substance, are accidental spills cleaned up immediately according to one of several prescribed methods?

____14. Are all types of rockets or propellant project work guided by such recommendations as specified by the National Association of Rocketry? (National Association of Rocketry, 1891 Massachusetts Avenue, McLean, Virginia 22101) Students should not "experiment" with rocket fuel propulsion devices.

B. Reagent safety

____15. In the process of mixing acid and water, are students instructed to add <u>acid</u> to <u>water</u> and stir carefully.

____16. Are volatile substances, which are spilled, safely removed?

____17. Are combustible materials stored in an enclosed area separated from other chemicals?

C. Glassware safety

____18. Is glassware which is to be heated of the pyrex variety?

____19. Is all glass tubing used with corks or stoppers fire-polished or have edges been beveled with emery paper?

____20. Is soap solution, water, or glycerin used on the tips of glass rods or tubing for lubrication before inserting into a cork or stopper?

____21. Are students instructed to avoid drinking from laboratory glassware?

D. Electrical safety

____22. Do you operate laser and maser devices? Are you following State regulations?

____23. Are all electrical devices properly grounded?

____24. Are wall plugs situated where water will not normally enter them?

____25. Are 240V outlets labeled?

____26. Are high-voltage sources properly shielded?

____27. Are microwave, X-ray, or electron emission devices properly shielded?

____28. Are there any loose electrical connections or frayed cords?

E. Safety equipment

____29. Do you have safety rules and procedures that a student must follow?

____30. Are safety precautions a part of every laboratory exercise?

____31. Are your fire extinguishers checked frequently for operability?

____32. Is there a fire blanket, eye wash station, safety shower, and complete first aid kit in the laboratory?

____33. Are your students supplied with and required to wear approved safety goggles?

____34. Is your laboratory equipped with a serviceable fume hood or ventilating fan?

____35. Are your chemicals stored separately from metallic equipment?

____36. Are incompatible chemicals separated?

____37. Do you frequently check the alkali metals for kerosene coverage, and white and yellow phosphorus for water coverage?

____38. Are acids and dangerous chemicals safely stored?

____39. Do you have a list of students in each class who are sensitive to bee stings, poison ivy, oak, and sumac?

____40. Do you remove spills or undesirable chemicals as suggested in the chemical disposal section of this manual?

____41. Do you check your laboratory for proper air movement during each working period?

F. First aid measures

____42. Is there a copy of First Aid and Personal Safety Manual (American National Red Cross) readily accessible to science teachers?

____43. Have all science teachers received recent (in the past five years) training in approved first aid measures for cuts, burns, chemicals in the eye, electric shock, shock treatment, snakebite, insect stings, and other measures that are appropriate for science labs?

____44. Is your first aid kit complete as recommended in other sections of this manual?

____45. Is a snakebite kit and a first aid kit taken on field trips?

APPENDIX A

Laser Facts and Regulations

Several facts have been established to indicate that lasers currently in use in classrooms can pose hazards for injury to both students and instructors. Some of these facts were uncovered through a survey conducted by the Food and Drug Administration, Bureau of Radiological Health, and State or occupational health agencies in seven states. The Bureau of Radiological Health presents the following facts and provides guidelines for laser safety:

FACTS

1. The survey found that Helium-Neon lasers account for 92 percent of lasers used in high schools and 79 percent of lasers used in colleges. Your laser is probably a Helium-Neon device.

2. The survey found that lasers specified or rated at 1.0 milliwatts radiated in the range of 0.19 to 3.0 milliwatts. Similar variations were measured for other specified powers. In general, the optical power specification is not a reliable index of the output.

3. Users of only half of the lasers surveyed had, or could locate, instruction manuals which contained any safety advice or information.

4. No laser surveyed had any statement of output power on the laser itself.

5. A value of 7 milliwatts has been stated to be the power from a He-Ne laser required to produce a retinal burn in experimental animals (Knowles, C. H., "The Physics Teacher," February 1972, pp. 70-72). This value was taken from the abstract of a research report (Ham, W. T., "Retinal Burn Thresholds for the Helium-Neon Laser in the Rhesus Monkey," Archives of Ophthalmology 84 (6): 797-809, 1970). The 7 milliwatt figure represents a calculated power that produces retinal burns in 50 percent of exposed monkeys. The actual experiments utilized five monkeys. The data showed that a raw unfocused beam entering the eye of 1.9 milliwatts for one second produced a retinal burn in one monkey.

6. Production of visible retinal burns has been independently reported in Rhesus monkeys exposed to 2.0 milliwatts for 1 second (Frisch, "Retinal Injury Thresholds from Argon Laser Radiations," Department of Army, Frankfort Arsenal, Memorandum Report m70-21-1, June 1970).

7. Human injury from a Helium-Neon laser has been reported (Armstrong, C. E., "Eye Injuries in Some Modern Radiation Environments," Journal of the American Optometric Association 41 (1): 55-62, 1970). A visible retinal burn was produced from an accidental exposure to a power of 2 milliwatts for an estimated one to two seconds.

8. Changes in retinal cells can be observed with the microscope after eye exposures to laser beams at powers less than those required for retinal burns ("Preliminary Documentation Report--Biological Aspects and Other Bases for the Performance Standard for Laser Products," BRH-DBE, October 1972). Deleterious effects at the microscopic level may occur at optical radiant powers perhaps as much as 100 times lower than powers expected to produce visible retinal burns.

The knowledge that a hazard can exist should be combined with prudent working practices. Although a federal radiation safety performance standard for lasers is being developed, it will not apply to lasers in use. To assist you in a safety program, the safety precautions listed below are recommended to minimize the risk of injury to students and other observers. These safety precautions, with which your students should be completely familiar, apply primarily to the widely used Helium-Neon laser devices. Other lasers, having substantially different output power or energy, wavelength, and emission durations, may require that additional precautions be taken. You are urged to implement the Laser Safety Action Program.

LASER SAFETY ACTION PROGRAM

1. Avoid direct viewing of the beam. Direct propagation of the laser beam from the laser into the eye of an observer should be avoided at all times. As a general practice, do not place any portion of the body in the beam. This practice becomes increasingly important as the output power of the laser device increases. Good work practices developed early will assist the individual in working safely later with higher output units.

2. Remove unnecessary objects from the path of the beam. Objects with mirror-like finishes reflect laser beams. Viewing the reflected beams should also be avoided. Demonstration equipment, such as support rods and bench surfaces, should be painted or treated to produce a dull, non-reflective surface. All optical components should be rigidly fixed with respect to their position to the laser.

3. Block the beam when it is not needed. Add a shutter or cap which can be operated to allow the beam to radiate ONLY when necessary for measurements or observations.

4. Terminate laser beams. All radiation beams from a laser should be terminated by nonreflective, absorbing material to prevent unnecessary propagation beyond the work area. Such targets should be fixed rigidly to prevent accidental displacement of terminating materials.

5. Prepare and test demonstrations without others present. Demonstrations should be prepared and tested by the instructor without others present. The possibility of an unexpected reflection should always be considered.

6. Deflect beam in a vertical plane. Complex experiments or demonstrations involving reflection or refraction should be conducted with the beam deflection angles contained in a vertical plane. The laser display system should be contained in a box open on the side(s), but closed on the ends, top and bottom. The height of the laser beam axis should be established at a level below or above the eye level height of the instructor or observers.

7. Affix expanding lens rigidly to laser. When the laser is used to illuminate large surfaces, such as in the viewing of holograms, beam-expanding lenses should be rigidly fixed to the laser.

8. Equip Laser with a key switch. The laser should be equipped with a key switch in the primary power circuit, rather than with the more commonly used toggle-type switch. Key switches are available from electronic supply stores for approximately $2.00.

9. Do not leave an operable laser accessible and unattended.

10. Reduce optical power. The optical power used should be reduced to the minimum necessary to accomplish the classroom objective. Neutral density filters or colored plastic can be used effectively to reduce radiated optical power.

Further information on laser safety is available. Single copies of a safety pamphlet may be requested at no charge from the following agency:

Office of Information (RH-50)
Bureau of Radiological Health
Food and Drug Administration
5600 Fishers Lane
Rockville, Maryland 20852

APPENDIX B

Alabama Law Relative To Safety Goggles

*1 (12). *Eye protective devices for pupils and teachers participating in certain courses.* (a) Every pupil and every teacher in the public schools shall wear industrial quality eye protective devices while participating in the following courses:

A. Vocational or industrial arts, shops or laboratories involving experience with:

1. Hot molten metals

2. Milling, sawing, turning, shaping, cutting or stamping of any solid materials

3. Heat treatment, tempering, or kiln firing any metal or other materials

4. Gas or electric arc welding

5. Repair or servicing of any vehicle

6. Caustic or explosive materials

B. Chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids.

(b) The board of education or other governing authority of each school shall furnish the eye protective devices prescribed in this section free of charge to the pupils and teachers of the school participating in the courses described in subsection (a) of this section. The county board of education or other governing authority shall furnish eye protective devices to all visitors to the courses heretofore named.

(c) "Industrial quality eye protective devices" as used in this section shall mean devices meeting the current standards of the American Standard Safety code for Head, Eye and Respiratory Protection, promulgated by the American Standards Association, Incorporated. (1965, 1st Ex. Sess., p. 219, appvd. April 5, 1965)

*From Public School Laws of the State of Alabama. (The Michie Company) 1969, p. 30